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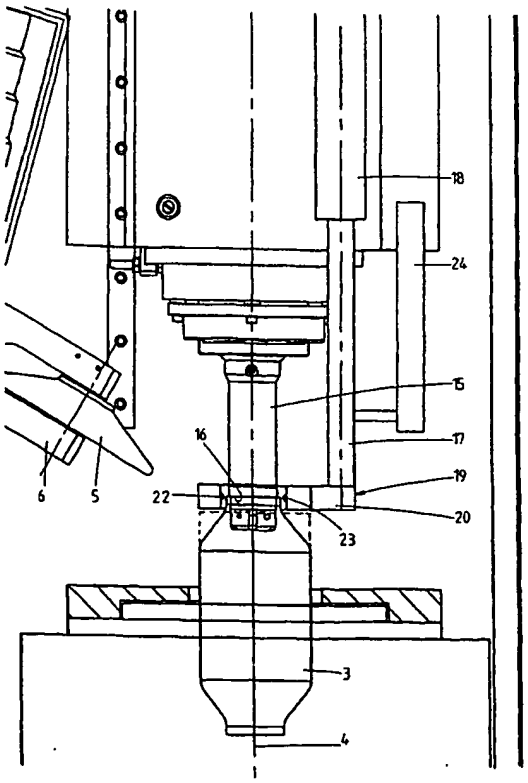
(54) Title: METHOD AND FORMING MACHINE FOR DEFORMING A WORKPIECE



(57) Abstract: The invention relates to a method and a forming machine for deforming a workpiece, such as a metal cylinder or plate (3), by means of a tool, in particular one or more forming rollers (5), wherein the workpiece and/or the tool are rotated about an axis (4) relative to each other, the tool move; through one or more deforming curves and at least part of the workpiece is deformed. During the deforming process, values of one or more coordinates of the position of the extreme: edge of the workpiece are measured, and one or more parameters of the deforming process is/are changed on the basis of the measured values.

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Method and forming machine for deforming a workpiece

The invention relates to a method for deforming a workpiece, such as a metal cylinder or plate, by means of a tool, in particular one or more forming rollers, wherein the workpiece and/or the tool are rotated about an axis relative to each other, the tool moves through one or more deforming curves and at least part of the workpiece is deformed. The invention furthermore relates to a forming machine for deforming a workpiece, which forming machine comprises a control unit.

Such a method and forming machine are known from European patent application No. 0 125 720. Said publication describes a forming machine comprising a control unit for controlling the movement of the forming roller. The control unit is connected to a detector for measuring the force exerted on the forming roller (by the workpiece) and to a detector for determining the position of the forming roller, whilst a memory is connected to the control unit for storing associated force/position values, and the control unit is adapted for controlling the movement of the forming roller in dependence on the force/position values that are stored in said memory.

Another example is described in WO 02/07097. Said publication relates to a method and a forming machine for deforming a hollow workpiece having at least one open end, wherein a first forming tool is placed into contact with the outer side of the workpiece and a second forming tool is placed in the cavity defined by the workpiece, into contact with the inner side of the workpiece, and the workpiece is deformed by means of tools.

In many cases, the length of the deformed portion of semi-manufactured products obtained by means of this type of methods and forming machines will be different from the

of the deforming curves in the direction of the axis of rotation and/or by changing the shape of said curves, for example gradually making them more concave, the elongation can be increased, and vice versa. By using a higher feeding rate and/or a lower rotational speed and/or by shifting the position of one or more of the deforming curves in a direction away from the axis of rotation and/or by changing the shape of said curves, for example gradually making them more convex, the elongation can be decreased.

Preferably, the values of one or more coordinates of the position of the extreme edge of the workpiece are measured at least at the end of each pass, more preferably during the entire deforming process. Thus, the deforming process can be adjusted continuously, without complicated calculations being required, and the intended length can be achieved quickly, i.e. preferably without additional deforming curves or other operations.

The invention furthermore relates to a forming machine for deforming a workpiece, such as a metal cylinder or plate, comprising a tool, in particular a forming roller, one or more driving means for moving said tool, a control unit comprising a memory, which unit is arranged for controlling the tool during the deforming process at least on the basis of deforming curves, the feed rate and/or the rotational speed with which the workpiece and the tool are rotated relative to each other, which parameters are stored in the memory. The forming machine is furthermore provided with at least one detector for measuring values of one or more coordinates of the position of the extreme edge of the workpiece.

The invention will now be explained in more detail with reference to the figures, which show various embodiments of the invention.

Fig. 1 is a top plan view of a first forming machine according to the present invention, which is provided with a detector.

Fig. 2 shows a detail of the top plan view of Fig. 1.

Positioned opposite the workpiece 3 is a tailstock 12, which is known per se, which head is mounted on the same machine bed 14 as the clamping device 2 and the slide group 7, capable of reciprocating movement on rails 13. The tailstock 12 is provided with a mandrel 15, whose (imaginary) central axis coincides with the axis of rotation 4 of the clamping device, which mandrel is provided with a annular stop shoulder 16 positioned a few centimetres from the end of said mandrel. Furthermore, a detector 19 is connected to the tailstock 12 via a rod 17 and driving means 18, such as a pneumatic or hydraulic cylinder, a servo motor or the like (note: the detector 19 is the only part that is shown in side elevation). In this embodiment, the detector 19 comprises a U-shaped element 20 at the end of the rod 17, the spacing between the legs thereof preferably being larger than the external diameter of the workpiece 3 that is to be deformed. A laser diode 22 and a laser sensor 23 may be connected to respective ends of said legs. In the activated condition of the laser 22, the laser beam will be positioned to the right or to the left of the mandrel 15, in such a manner that said beam is not interrupted by the mandrel 15. The detector 19 can be reciprocated by the driving means 18 in a direction parallel to the axis of rotation 4 of the clamping device 2. The rod 17 is furthermore connected to a known linear position sensor 24, for example a linear encoder, which is fixedly connected to the tailstock 12.

The clamping device 2, the driving means 10, 11, 18, the detector 19 and the linear position sensor 24 are connected to a control unit 25 (schematically indicated) in a known manner. Stored in said unit 25 are *inter alia* the deforming curves to be followed by the forming roller 5, the feed rates and the rotational speed of the clamping device 2.

In this example, a cylindrical workpiece 3 is deformed into a housing, e.g. for a catalytic converter substrate for use in an exhaust system for an internal combustion engine. The deforming curves to be followed by the forming roller 5, the feed rates and the rotational speed of

tudes, and the control unit may be so arranged that the feed rate is changed first, for example, and that one or more deforming curves is/are subsequently shifted inwardly if a specific threshold value is exceeded.

If there is a risk of the deformed portion becoming too short, the feed rate is decreased and/or the rotational speed is increased, or one or more of the deforming curves is/are shifted outwardly, i.e. in a direction away from the axis of rotation 4.

In cases in which not only the diameter of the extreme edge and the length of the deformed portion of the finished product are specified, but also the changes in the shape of the wall of the deformed portion, for example, the feed rate, the rotational speed and the force exerted on the workpiece by the forming roller (for parts present on a forming tool) can be successively adapted, for example, whilst leaving the deforming curves unchanged.

During the final pass, the end of the workpiece is deformed on the mandrel and against the annular stop shoulder, so that the internal diameter and the length of the obtained extreme edge of the semi-manufactured product are precisely defined

Figs. 3-5 show variants of the detector 19. In Fig. 3, the forming machine is equipped with a detector that is provided with a series of a laser diodes and a series of corresponding laser sensors positioned opposite thereto. In that case the position of the extreme edge of the workpiece can be determined on the basis of the number of laser beams that are interrupted by said edge. This enables a simplification of the control loop according to which the detector 19 scans the extreme edge of the workpiece or, if the series is sufficiently long, said control loop may even be left out altogether (Fig. 4). In that case sufficient sensors will be present for following the position of the extreme edge without moving the detector.

Besides carrying out contactless measurements, it is also possible to scan the extreme edge of the workpiece by

tating workpiece and a rotating tool, as described in International application WO 02/062500, for example. Furthermore it is for example possible to use the invention for eccentrically or obliquely deforming workpieces.

particular one or more forming rollers (5), one or more driving means (10, 11) for moving said tool (5), a control unit (25) comprising a memory, which unit (25) is arranged for controlling the tool (5) during the deforming process at least on the basis of deforming curves, the feed rate and/or the rotational speed with which the workpiece (3) and the tool (5) are rotated relative to each other, which parameters are stored in the memory, **characterized in that** the forming machine (1) is furthermore provided with at least one detector (19) for measuring values of one or more coordinates of the position of the extreme edge of the workpiece (19).

7. A forming machine (1) according to claim 6, wherein the control unit is arranged for changing the position and/or the shape of one or more of the deforming curves being passed through during the deforming process, the feeding rate and/or the rotational speed with which the tool (5) and the workpiece (3) are rotated relative to each other on the basis of the measurement or measurements obtained by means of the detector (19) or detectors, with the proviso that, if the shape of one or more of the deforming curves is changed, no locally reduced portions will be imposed on the deformed portion.

8. A forming machine (1) according to claim 6 or 7, wherein the detector (19) comprises a series of sensors.

9. A forming machine (1) according to any one of the claims 6-8, comprising a forming tool, such as a mandrel (15) or a spindle (28), on which at least the extreme edge of the workpiece (3) can be deformed.

10. A forming machine (1) according to claim 9, wherein the forming tool (15; 28) is provided with a stop (15), by means of which the length of at least a portion of the workpiece (3) can be determined.

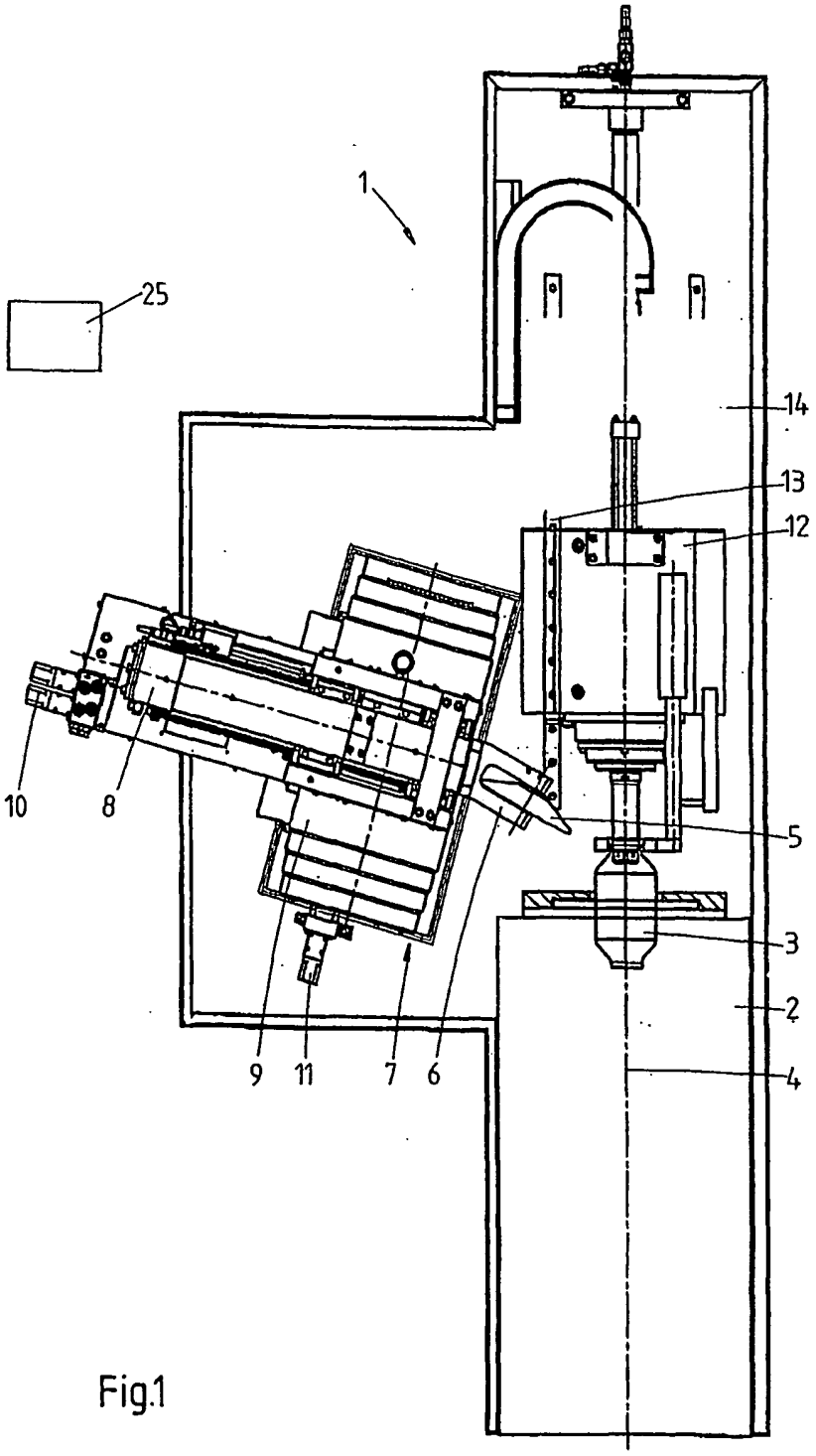

Fig.1

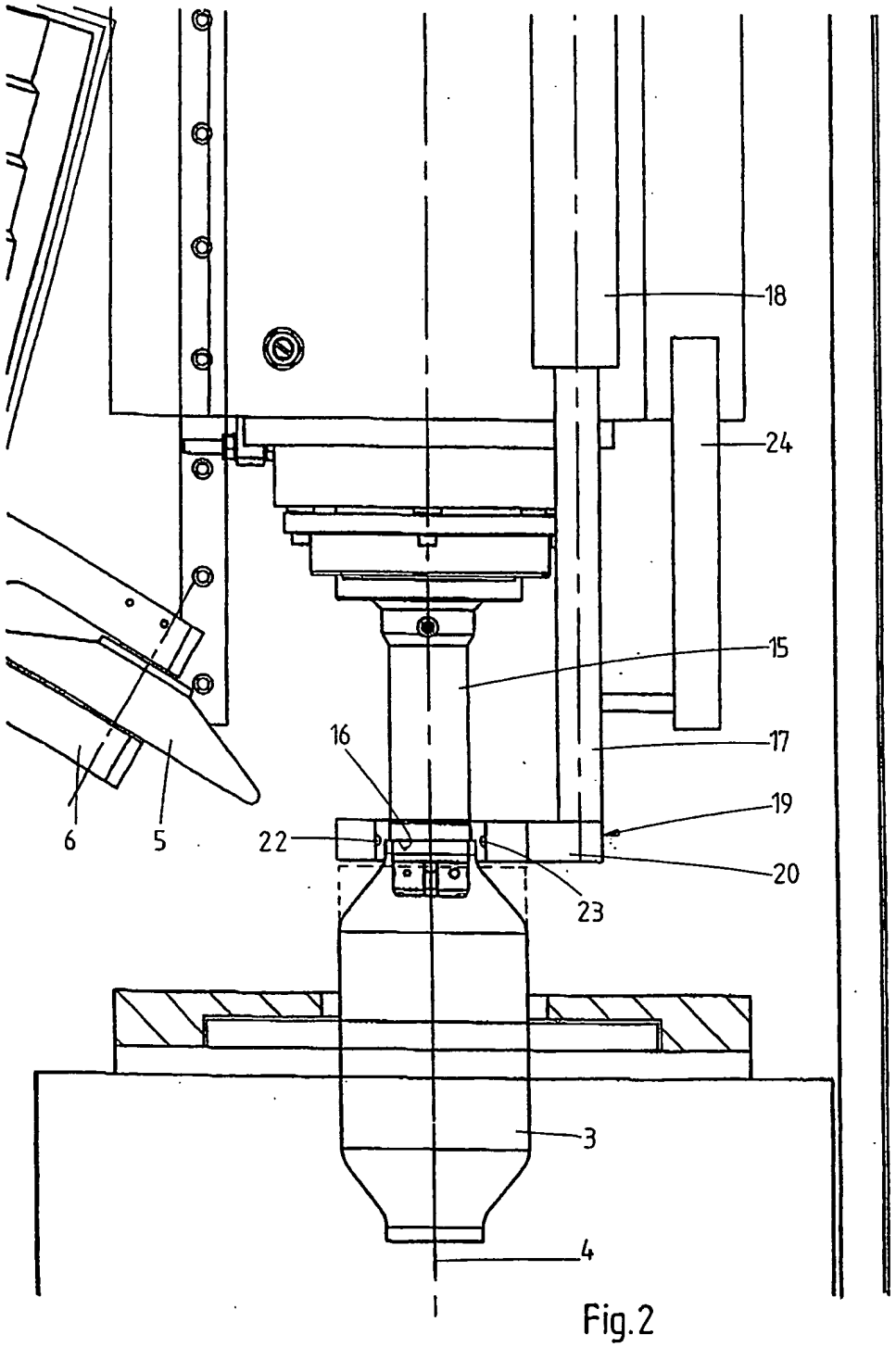

Fig.2

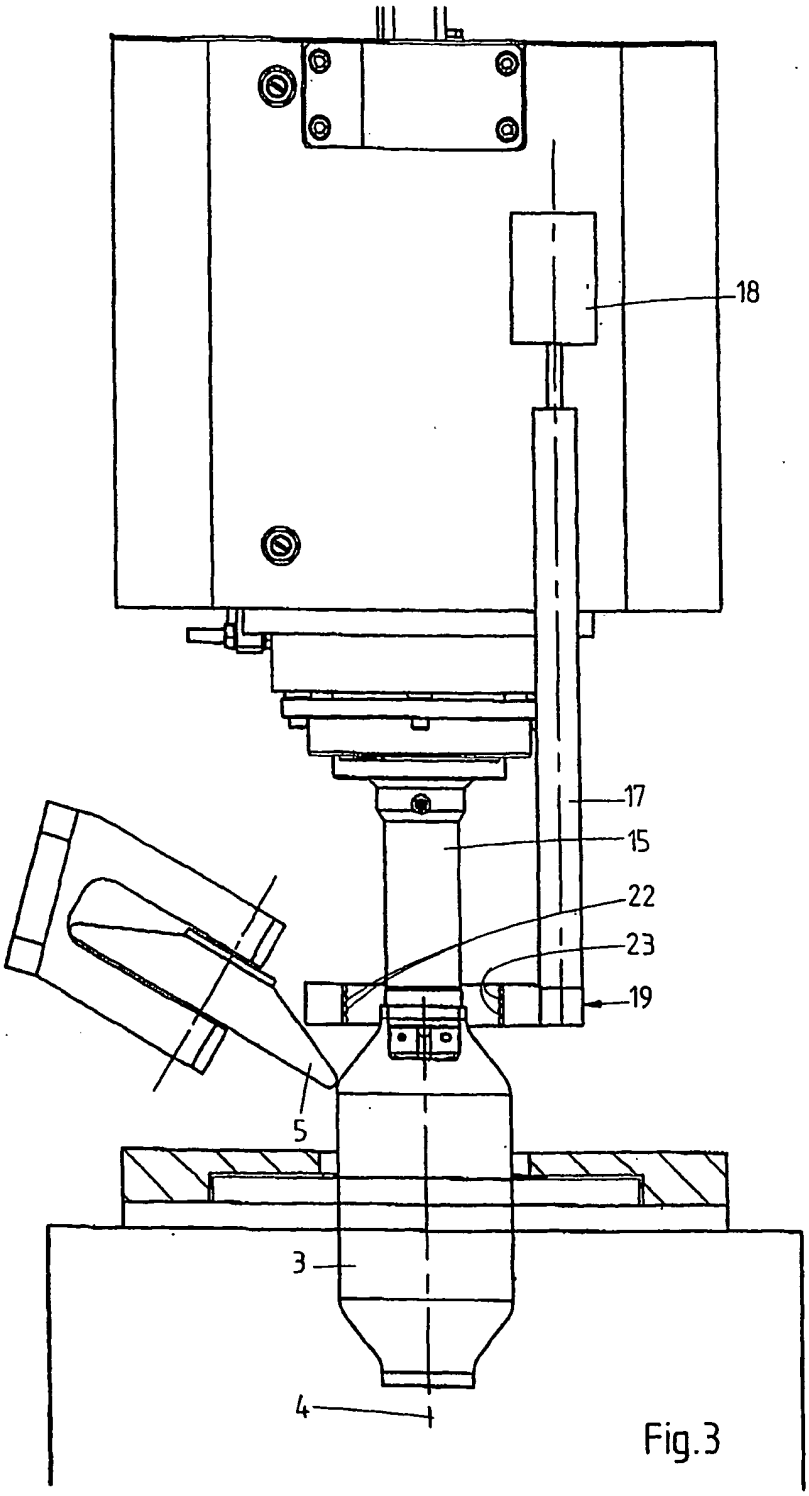

Fig.3

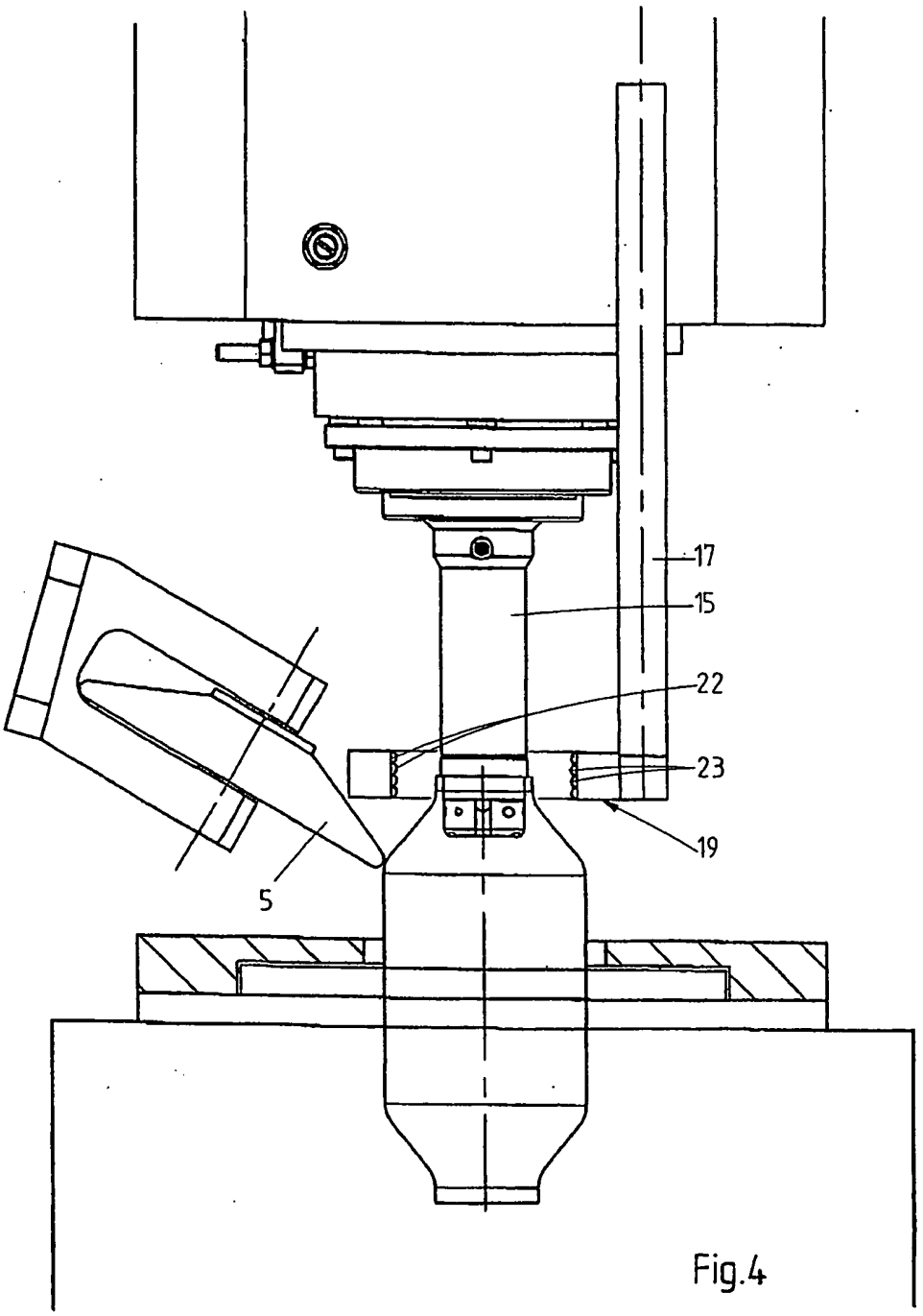

Fig.4

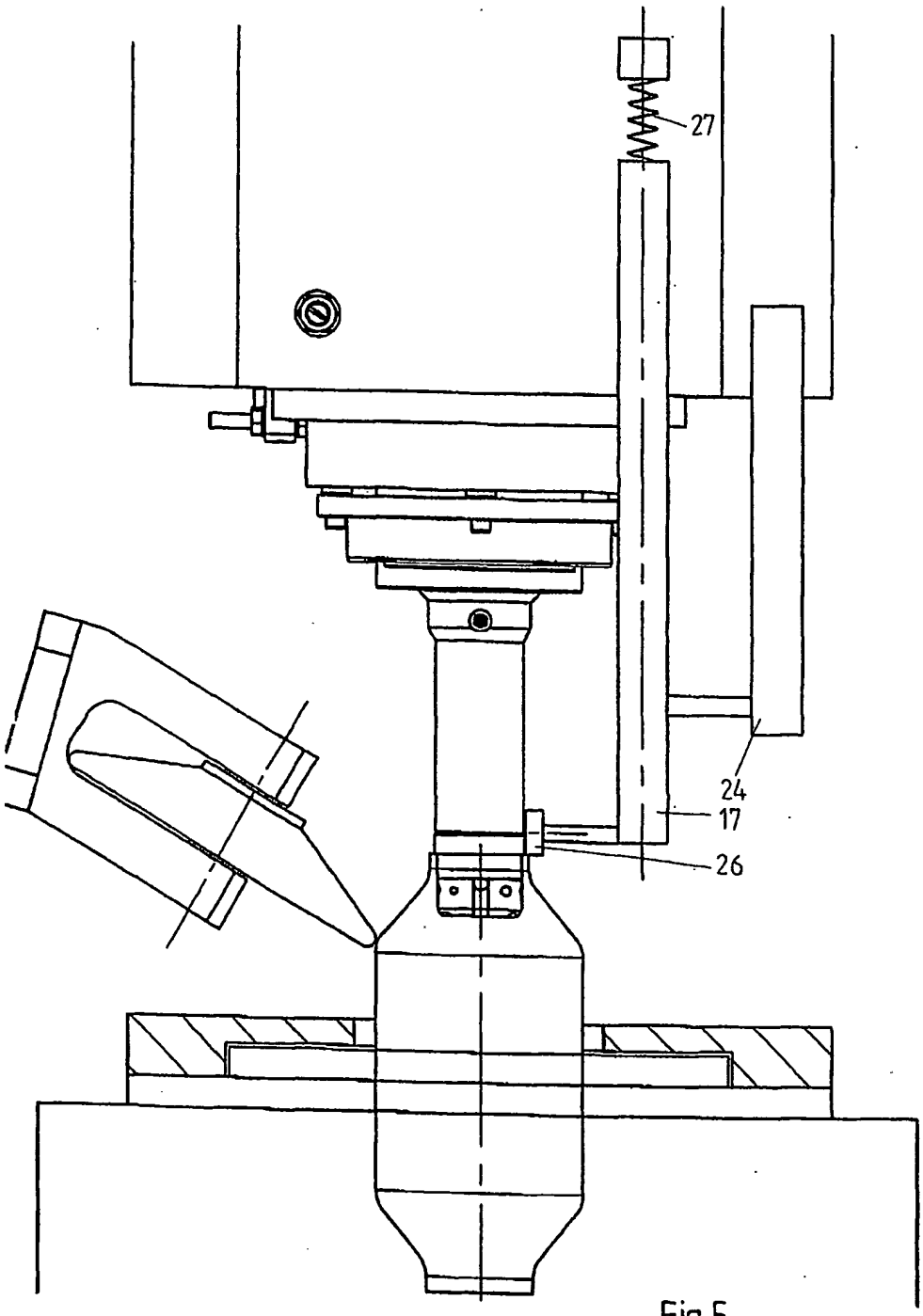

Fig.5

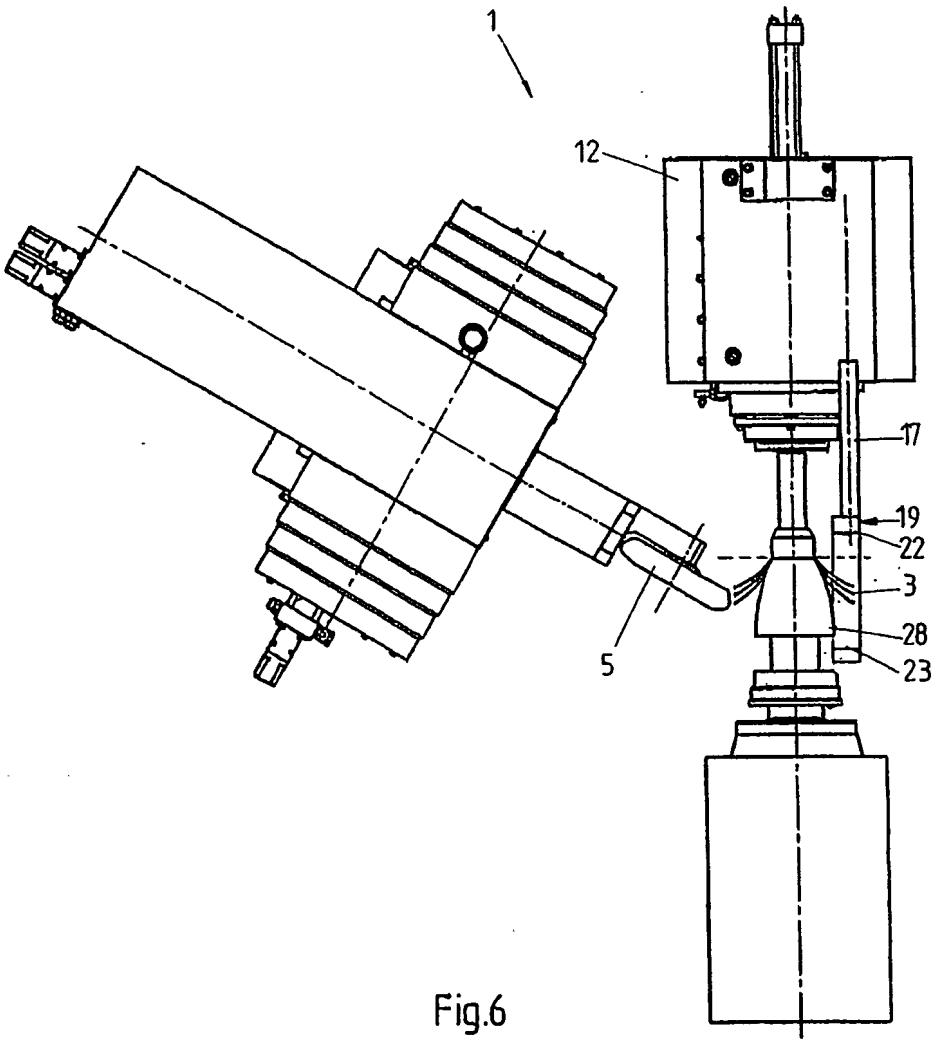

Fig.6

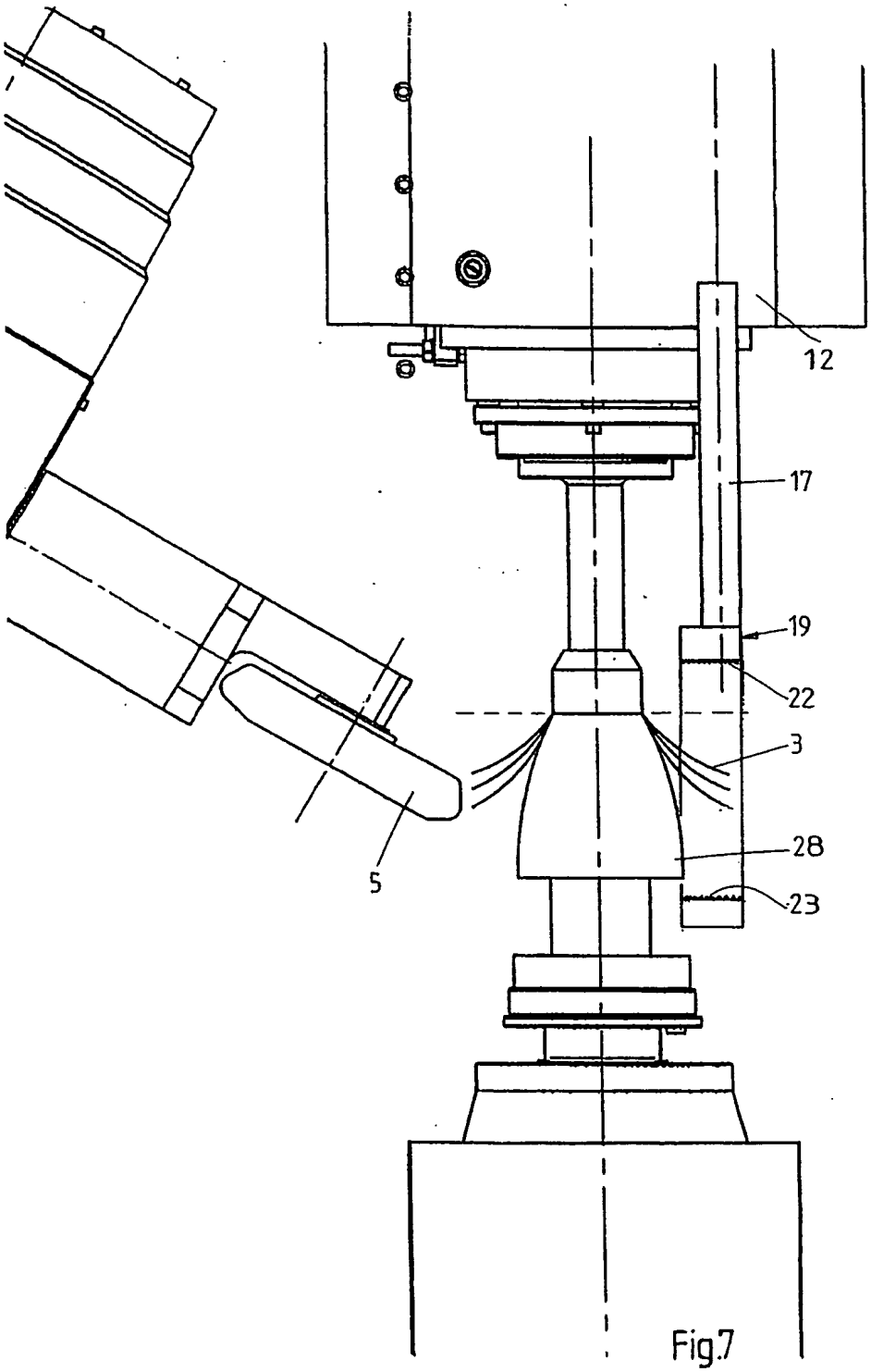

Fig.7

INTERNATIONAL SEARCH REPORT

Int. onal Application No
PC., NL2004/000776

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B21D22/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 02/053307 A (POLLKOETTER GUENTER ; LEICO GMBH & CO WERKZEUGMASCHB (DE)) 11 July 2002 (2002-07-11) the whole document	1-10
A	JP 58 003729 A (MATSUSHITA DENKO KK) 10 January 1983 (1983-01-10) the whole document	1,6
A	PATENT ABSTRACTS OF JAPAN vol. 0070, no. 74 (M-203), 26 March 1983 (1983-03-26) & JP 58 003729 A (MATSUSHITA DENKO KK), 10 January 1983 (1983-01-10) abstract	1,6

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
20 January 2005	28/01/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ris, M

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INTERNATIONAL SEARCH REPORT

rmation on patent family members

In ional Application No
PCT/NL2004/000776

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